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Edward F. Neuhauser and Michael R. Malecki
Department of Agricultural Engineering
Cornell University
Ithaca, NY 14853

and

Zoran V. Cukic
Department of Water Supply, Sewerage and Pollution Control
Institute for the Development of Water Resources "J. Cerni"
Bulevar Vojvode Misica 43
11000 Belgrade, Yugoslavia

EPA Project Officer
C. A. Callahan

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OFFICE OF RESEARCH AND DEVELOPMENT
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METAL CONTENT OF EARTHWORMS IN SLUDGE AMENDED SOILS: UPTAKE AND LOSS

Edward F. Neuhauser*, Michael R. Malecki*, and Zoran V. Cukic**

ABSTRACT

The widespread practice of landspreading of sludge has raised concern about increasing concentrations of potentially toxic metals in soils, with the possibility of these metals adversely impacting terrestrial and aquatic ecosystems. Earthworms, as one of the largest components of the soil biota, are useful indicators of potentially toxic soil metal concentrations. This study describes the metal content of five metals (Cd, Cu, Ni, Pb, and Zn) in one earthworm species, Allolobophora tuberculata Eisen, as a function of varying soil metal concentrations in the same soil type and the ability of the earthworms to bioconcentrate the five metals. The rate of uptake of the five metals in earthworms with initially low concentrations of metals placed in a soil with high metal concentrations was evaluated for a 112 day period. The rate of loss of the five metals in earthworms with initially high metal concentrations placed in soil with low metal concentrations was also examined.

INTRODUCTION

The increased recycling of sludge on land has raised concerns over possible increases of potentially toxic metal concentrations in treated soils, with subsequent metal contamination of terrestrial and aquatic ecosystems. One way of approaching this problem is to study the impact of high soil metal concentrations on a lower trophic level of the soil ecosystem, specifically earthworms. Previous field studies on metal uptake by earthworms (1-6) using a variety of soil types, does not give a clear picture of metal content of earthworms as a function of soil metal content. In this study, the availability of a sludge disposal site on a single soil type permitted an analysis of earthworm metal content over a range of soil metal concentrations.

Little is known about the time required for an earthworm's body burden of a metal to equilbriate after exposure to a soil with a higher or lower metal concentration than the previous soil the earthworm inhabited. This study evaluated the loss and uptake of metals from one earthworm species switched into different habitats.

MATERIALS AND METHODS

Earthworms and soil were collected at a land disposal site which is a Mardin Channery silt loam (coarse, loamy, mixed Mesic Typic Fragiochrept). During 1975-79 the site received anaerobically digested

*Dept. of Agricultural Engineering, Cornell University, Ithaca, NY 14853
**Institute for the Development of Water Resources "J. Cerni", Bulevar Vajvode Misica 43, 11000 Belgrade, Yugoslavia

soil, a Kendaia silt loam (fine-loamy, mixed non-acid mesic Aeric Haplaquept) which has not received any exogenous metal input. Earthworms (Allolobophora tuberculata Eisen)and soil samples were collected at 14 locations, with earthworms being obtained by hand sorting.

The loss and uptake experiments were done by: (a) placing worms with high body concentrations of metals into soil with low metal concentrations, and (b) placing worms with low body concentrations of metals into soils with high concentrations of metals. Approximately 25 kg of soil was placed into trays 55 cm long by 43 cm wide by 13 cm deep, with three replicates for each treatment. Approximately 180 worms were added to each tray with the trays being placed in incubators at 20°C with soil moisture content maintained at 30%.

Prior to each metal determination, 20 - 25 earthworms were permitted to void gut contents for 24 hours at 20°C and soil samples were thoroughly mixed and sieved through a 4 mm screen. The metal content of earthworms and soil was determined by dry ashing the samples at 450°C for 12 hours(7). Ashed samples were placed into 100 ml glass beakers and treated with 10 ml of 8 N nitric acid for 12 hours on a steam bath and then filtered. Metal determinations were done using an Instrumentation Laboratory Model 451 atomic absorption spectrophotometer with background correction.

RESULTS AND DISCUSSION

The metal concentrations of the earthworms and soil are shown in Figure 1. Bioconcentration of metals in earthworms occurs when the metal concentration in the earthworm tissue is greater than the metal concentration in the soil. Cd and Zn in our study were always bioconcentrated in the earthworms. Previous studies (1-6) have also found that Cd is bioconcentrated in earthworms. Zn is bioconcentrated in earthworms at low soil concentrations of Zn (1,2,4,5) but is not always bioconcentrated at higher soil Zn concentrations (3). Cu was found to be bioconcentrated at low soil Cu concentrations in this study and not to be bioconcentrated at higher soil Cu concentrations agreeing with a previous studies (4-6). No bioconcentration of Ni was found in this study, agreeing with previous studies (4-6). Other studies have

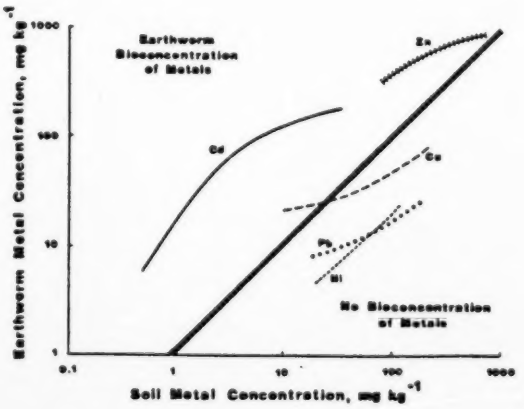

Figure 1. The relationship of soil metal concentration to earthworm metal concentration. Bold solid line is y = x.

found bioconcentration of Pb to occur (1, 3-5), while this study found no bioconcentration of lead at the soil metal concentrations evaluated.

Earthworms grown in a soil with a high metal concentration, when placed in a soil with a low concentration of metals, lose their body burden of Cd and Zn slowly over time (Figure 2). The Cu, Ni and Pb body burden of the worms appears to be lost rapidly. Earthworms grown in a soil with a low metal concentration, when placed in a soil with a high concentration of metals, will gradually increase the Cd and Zn body burden for up to 112 days. The body burden of Cu, Ni and Pb reached their highest concentration after six days and then gradually decreased for the remaining 106 days of the experiment. Cd and Zn take a much longer time period to come to equilibrium in earthworm tissues, while Cu, Ni and Pb appear to come to equilibrium rapidly.

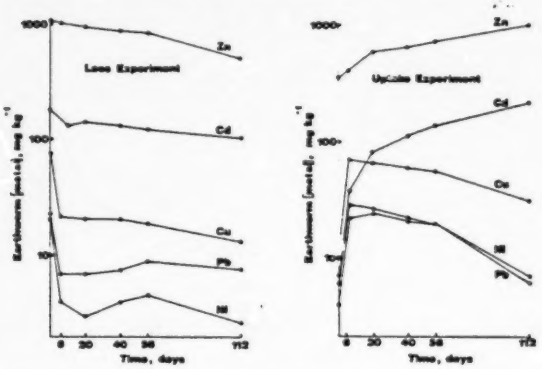

Figure 2. The relationship of earthworm metal concentration to time for the loss and uptake experiments.

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